

## POWER SUPPLY DEVICE

Field Of The Invention

The present invention relates to power supply devices, in particular in vehicle electrical systems.

5    Background Information

Traditional power supply devices in motor vehicles have a generator, a battery, and various electrical consumers of the vehicle electrical system. The generator is driven by the internal combustion engine of the vehicle via suitable connecting means, e.g., the belt drive, and supplies the electricity required to charge the battery and supply power to the consumers. The output voltage of the generator is regulated to the desired level by an assigned voltage regulator and/or generator regulator, actual output voltage  $U_1$  of the generator optionally being varied within certain limits and adapted to preselectable requirements.

10      15    The generators customarily used are separately energized three-phase generators having an excitation winding through which an excitation current flows that is supplied by the battery and is switched by the generator regulator after activation of the ignition switch of the vehicle ("ignition on"). In order for a generator to be able to "start" at all, it needs the excitation current from the battery in the start phase. The  
20      25    excitation current creates a magnetic field in the rotor of the generator, thereby inducing a voltage in the stator winding of the generator when the rotor is rotating.

Since vehicle electrical systems need different voltages to supply the various electrical consumers, motor vehicles are known to use power supply devices that  
25      30    include multiple voltage systems at different voltages. Such an automotive power supply device is described in German Patent Application No. DE 38 12 577, for example, and includes two generators supplying voltages  $U_1$  and  $U_2$  to charge storage devices, i.e., batteries, and the assigned electrical consumers of the vehicle electrical system. Each generator is assigned its own battery. There is no provision for complete decoupling of the individual voltage systems.

Another power supply for a vehicle electrical system using two generators is known from German Patent Application No. DE 101 06 723, in which a PWM inverter is provided for each generator designed as a three-phase generator having an excitation winding and stator windings, a connection to one battery at a time being establishable via this PWM inverter. The generators supply different output voltages via which two partial vehicle electrical systems are supplied with power. No details are given about the start phase of the generators.

#### Summary Of The Invention

- With complete decoupling of the individual voltage systems, in particular two systems, the second generator does not have the excitation current required for starting. When using only one battery in particular, the second generator, i.e., the generator that is decoupled from the battery, does not have the excitation current required for starting. Therefore, an object of the present invention is to find a solution to this problem and ensure that after actuation of "ignition on," the second generator will also receive a sufficiently high excitation current that will allow it to be started reliably. This object is achieved by a power supply device according to the present invention.
- The power supply device according to the present invention has the advantage that the excitation current required for starting is reliably supplied to the second generator, thereby ensuring complete functionality of the two generators. This advantage is achieved by providing additional connection options in the form of connecting means between the excitation winding of the second generator and a charge storage device, these means being switched at least temporarily so that a conducting connection is established. The conducting connection is advantageously begun with the operation of the ignition switch and is maintained until the generator has started and is generating an output current. In particular an additional connection is established between the voltage system together with the battery and the second generator, which does not belong to this voltage system.

It is advantageous in particular to establish the additional connection via a voltage transformer, which is advantageously designed as a bidirectional d.c./d.c. transformer and is thus able to conduct power in both directions and equalizes

voltage differences prevailing in the two voltage systems, i.e., adjusts the voltages. It is then possible for two generators to supply power to the voltage system including the battery. The excitation current required for the second generator is supplied "in reverse" from the battery via the d.c./d.c. transformer.

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In another advantageous embodiment of the present invention, the additional connection is established by a diode, using, if necessary, additional components, in particular a resistor. This has the advantage that decoupling is obtained when there is a low generator voltage on the second generator, whereas under the condition that 10 the voltage of the second generator is higher than the voltage of the first, there is again decoupling of the two voltage systems. Advantageously, this does not require separate switching means.

In another advantageous embodiment of the present invention, the additional 15 connection is established by a switch, either a relay or an electronic switch, advantageously a transistor switch. At "ignition on," the switch is closed and the connection to the battery is established, so that an excitation current may also flow in the second generator. After ramp-up of the second generator, the switch is opened again and the two voltage systems are again decoupled from one another. One of 20 the two voltage systems may be advantageously supplied with power by both generators in parallel operation of the two generators, in which case the two generators are required to have the same output voltage.

If a generator regulator having a sense path to the first voltage system, i.e., vehicle 25 electrical system, is used for the second generator, the excitation current for starting the second generator may flow over this sense path. In addition, a preselectable degree of coupling of the two voltage systems via an internal wiring of the sense path to the regulator may be established in an advantageous manner.

30 In another advantageous embodiment of the present invention, the excitation current for starting up the second generator is obtained from an additional charge storage device which is part of the second voltage system and is designed as an extra battery, a capacitor or a SuperCap, for example. Complete decoupling of the two voltage systems, i.e., vehicle electrical systems, is then possible.

## SUBSTITUTE SPECIFICATION

Brief Description Of The Drawings

Figure 1 shows a first exemplary embodiment of the present invention.

Figure 2 shows a second exemplary embodiment of the present invention.

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Figure 3 shows a third exemplary embodiment of the present invention.

Figure 4 shows a fourth exemplary embodiment of the present invention.

10 Figure 5 shows a fifth exemplary embodiment of the present invention.

Detailed Description

Figure 1 shows a first exemplary embodiment of the present invention. A first generator G1, e.g., an externally regulated three-phase generator, is connected at the voltage end to the charge storage device, i.e., battery B1, and charges it during normal operation. Generator G1 and battery B1 also have a ground connection in the usual manner. Consumers V1 may be connected to battery B1 and/or generator G1 via ignition switch Z and any other switches S1 that are provided, if necessary. In addition to stator windings (not shown), generator G1 also includes an excitation winding E1 and a voltage regulator, i.e., generator regulator R1, which regulates the excitation current flowing through excitation winding E1 in a known way and thus regulates desired output voltage U1 of generator G1. These elements constitute a first voltage system, i.e., vehicle electrical system.

25 In addition, a second generator G2 having its own voltage regulator R2 and an excitation winding E2 is also present, this generator being used to supply power to consumers V2 which may be turned on or off via switches S2. The output voltage of generator G2 is regulated to a voltage U2 by voltage regulator R2. Switch S2, consumer V2, and generator G2 having excitation winding E2 and voltage regulator 30 R2 form a second voltage system, i.e., vehicle electrical system, which is decoupled from the first voltage system, i.e., vehicle electrical system.

An additional connection between the two voltage systems, i.e., vehicle electrical systems, is established via a voltage transformer W, which is made possible by the

approach according to the present invention. Without this additional connection, second generator G2 would not have excitation current IE2, which is required for starting, through excitation winding E2 with complete decoupling of the two voltage systems and the generator would not be able to start.

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By coupling the two voltage systems via the additional connection by a voltage transformer W, excitation current IE2 required for starting may be supplied to generator G2 from battery B1. Excitation current IE2 required for second generator G2 is supplied in "reverse" via d.c./d.c. transformer W from battery B1. First 10 generator G1, i.e., its excitation winding E1, is connected to battery B1 in the usual manner after operation of the ignition switch, so that an excitation current IE1 flows and allows the starting operation of generator G1.

Voltage transformer W, designed as a bidirectional d.c./d.c. transformer, for 15 example, which is thus capable of delivering power in both directions and equalizes voltage differences prevailing in the two voltage systems, i.e., adjusts the voltages, also makes it possible to supply power to the first voltage system, which includes battery B1, via two generators G1 and G2. In the exemplary embodiment according to Figure 1, a dual-voltage vehicle electrical system may be created, having  $U_1 = 20$  12 V and  $U_2 = 36$  V, for example, each [[in]] a nominal voltage or  $U_1 = 14$  V and  $U_2 = 42$  V.

Figure 2 shows another exemplary embodiment of the present invention. It includes the same components as in the exemplary embodiment according to Figure 1 except 25 for voltage transformer W. The additional connection between the two voltage systems and thus the coupling of the two voltage systems are established via a diode D and optionally a resistor Ri and other components, if necessary. Diode D is installed in such a way that the cathode is connected to generator G2 and the anode is connected to generator G1, so that the diode is able to conduct a current from 30 battery B1 to excitation winding E2 if no voltage has been induced in generator G2. The excitation current necessary for starting is supplied from battery B1 to second generator G2 via this connection.

At a low generator voltage  $U_2$  of second generator G2, a connection of the second voltage system to the first is established, while under the condition that voltage  $U_2$  of second generator G2 is higher than voltage  $U_1$  of first generator G1, there is again decoupling of the two voltage systems, so to speak, because diode D is

- 5 nonconducting when  $U_2 > U_1$ . It is advantageous that separate switching means are not required here.

Figure 3 shows a third exemplary embodiment of the present invention. Except for the voltage transformer, it includes the same components as the exemplary

- 10 embodiment according to Figure 1. The additional connection between the two voltage systems and thus excitation winding E2 of generator G2 to battery B1 is established via a relay or a switch S3 by which excitation current IE2 needed for starting is then supplied.

- 15 Switch S3 may also be an electronic switch, advantageously a transistor switch. At "ignition on," switch S3 is closed and the connection to battery B1 is established, so that an excitation current IE2 is also able to flow in second generator G2. After ramp-up of second generator G2, switch S3 is opened again and the two voltage systems are decoupled from one another again. One of the two voltage systems, in particular  
20 the first, may advantageously be supplied with power by both generators in the case of parallel operation of two generators G1 and G2, in which case the same output voltage ( $U_1 = U_2$ ) is then required of both generators G1 and G2, and switch S3 is closed. Switch S3 may be triggered via a control unit (not shown), for example.

- 25 Figure 4 shows a fourth exemplary embodiment of the present invention. Except for the voltage transformer, it includes the same components as the exemplary embodiment according to Figure 1. The additional connection between the two voltage systems and thus excitation winding E2 of generator G2 to battery B1 is accomplished via a relay or a sense path SP via which excitation current IE2 needed  
30 for starting is then supplied. The prerequisite for this embodiment is that generator regulator R2 of generator G2 has a sense path SP to the first voltage system, i.e., vehicle electrical system. For example, voltage information is also relayed over such a sense path. The internal wiring of sense path SP is responsible for the degree of coupling of the two voltage systems.

## SUBSTITUTE SPECIFICATION

Figure 5 illustrates a fifth exemplary embodiment of the present invention. Except for the voltage transformer, it includes the same components as the exemplary embodiment according to Figure 1. However, there is no additional connection between the two voltage systems and thus excitation winding E2 of generator G2 to battery B1, so that there is complete decoupling of the two voltage systems. The required excitation current for starting generator G2 is supplied by an extra battery ZB in the second voltage system with a connection established after actuation of the ignition switch and maintained until the generator G2 has started and supplies an output voltage. A capacitor or a SuperCap may also be used as the extra battery.

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At least to a certain extent, these exemplary embodiments may also be combined with one another with appropriate circuit adjustments.